**Beams-doc-942**

# Seeing Antiprotons with the Damper Board

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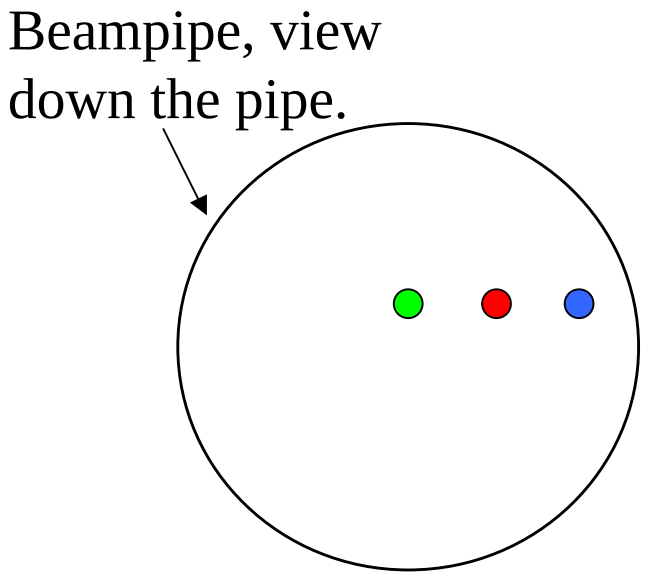
# Overview

- Goal is to demonstrate the technique for cancellation of the proton contamination on the antiproton cables.
- We will show that parts of the technique work but we do not yet have a full, quantitative demonstration.
- We expect this demonstration to converge soon.
- This talk is a status report.

# Configuration for These Tests

- BPM HA15 during the shot set up at about 4:30 PM on Dec 4.
- All 4 cables instrumented.
- Damper board produces I and Q signals for about 9.7 turns for each of the 4 cables.
- Define notation used in this talk:
  - A and B: signals on the proton direction cables.
  - C and D: signals on the pbar direction cables.

# Predicting Pbar Position




The test: can we measure the Pbars to be where they are predicted to be?

- Central orbit.
  - Measured with protons only before helix opened.
- Proton orbit:
  - Measured with protons only after helix opened.
- Predicted Antiproton orbit:
  - Shift wrt central orbit is equal and opposite to that of proton orbit.

# Definition of A and B

$$I_A = \sum_n I_n$$

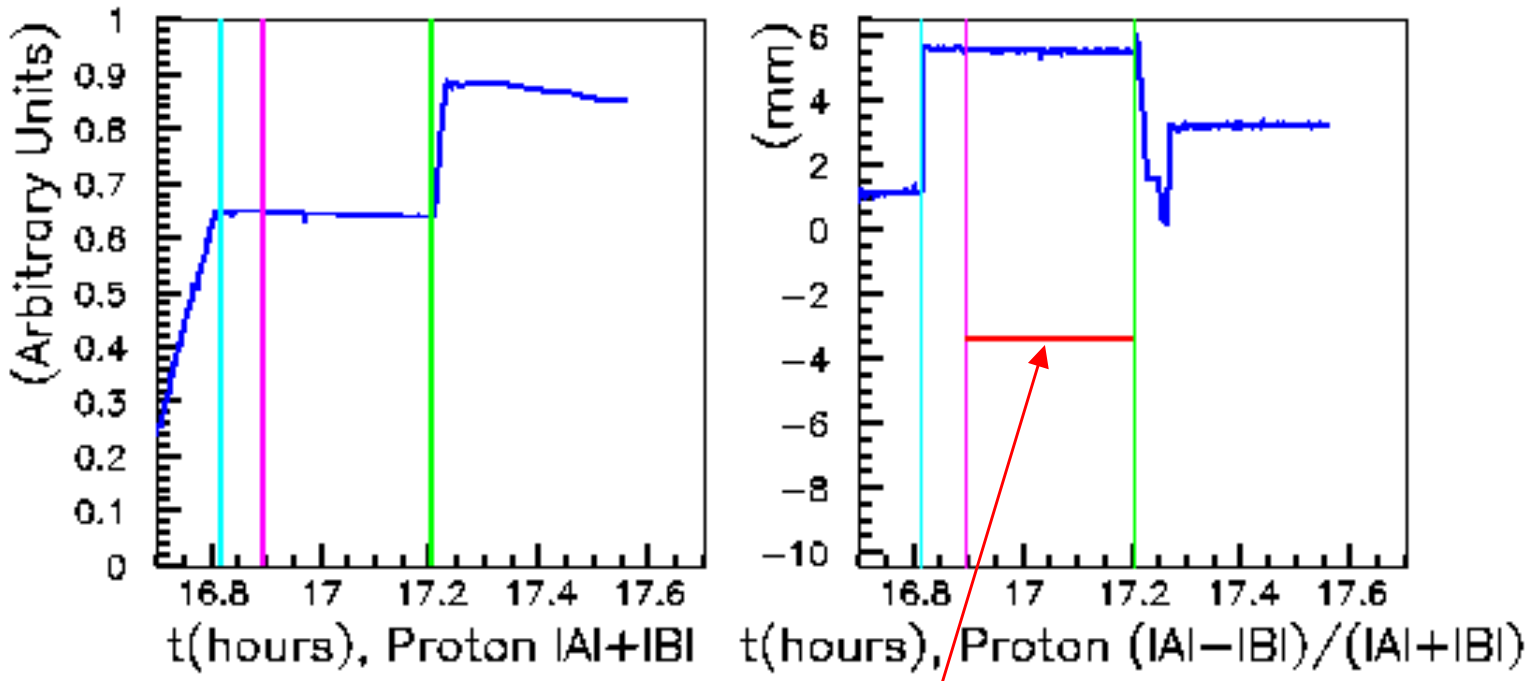
$$Q_A = \sum_n Q_n$$

$$A = Complex(I_A, Q_A)$$

- $I_n$ and $Q_n$ are the outputs of the damper board DDC.
- New ($I_n$,$Q_n$) every ≈99 ns.
  - Exactly ¼ of time between bunches.
- Sum runs over all data, about 9.7 turns.

- Similarly for B, C, D.
- Cancellation of proton contamination on C and D will be discussed later.

# Proton Information




Helix opens

Pbar injection starts

Ramp 150 to 980 GeV

Predicted Pbar position: Central-(Proton-Central).

Define $A_0$, $B_0$, $C_0$, $D_0$ as values just after helix opens.

# Notes on Previous Slide

- During energy ramp, the bunch gets shorter and the power at 53 MHz increases. This causes the A+B signal to change with energy. Will be calibrated out.
- Prediction of Pbar position only valid from Pbar injection to start of ramp.
  - Central orbit may move during ramp, injection point cogging and low beta squeeze.

# Removing Proton Contamination

$$C'(t) = \frac{C(t) - \frac{C_0}{A_0} A(t)}{1 - r_p r_{\bar{p}}}$$

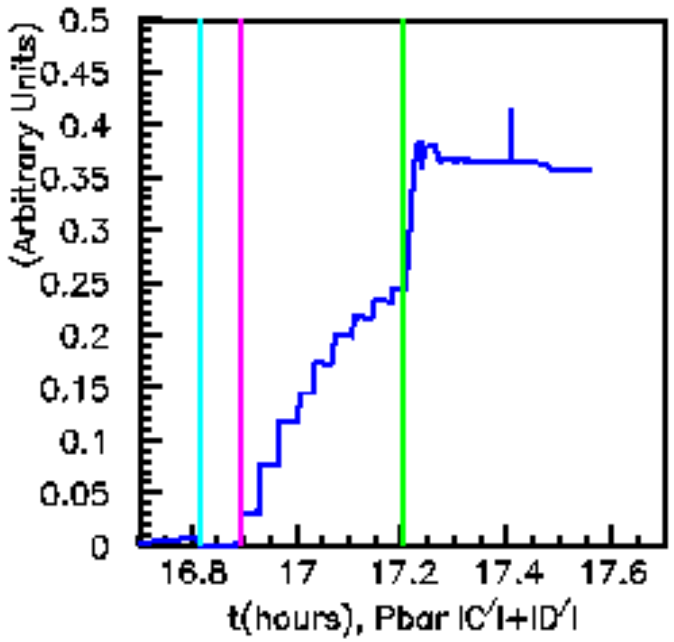
$$r_p = \frac{C_0}{A_0}$$

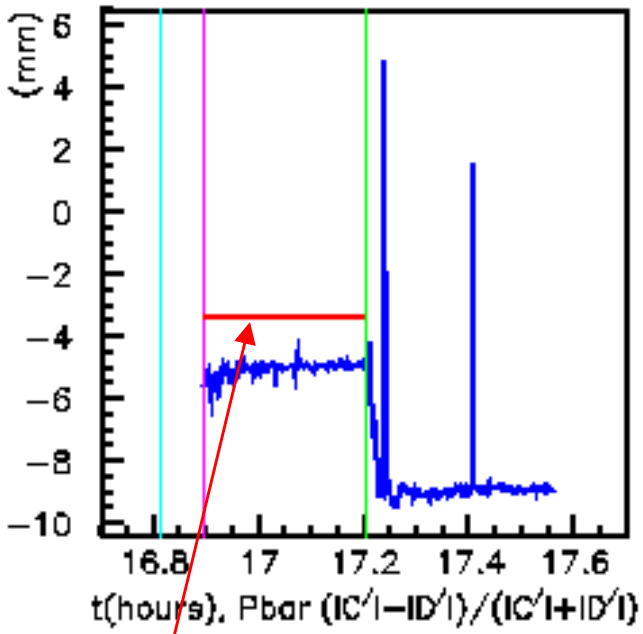
- Similarly for D.

- Approximation: In the following pages we set the denominator to 1 and hope it's good enough.

- Equation (9) in beams-doc-884. (or talk by Jim Steimel).
- $C_0$ and $A_0$ measured using protons only.
- Ratios $r_p$ and $r_{pbar}$ are directionality of the plates times transmission coeff's.
- Need measurements with anti-protons only to measure $r_{pbar}$.
  - These are planned.

# Pbar Signals After P Cancelation




Helix opens

Pbar injection starts

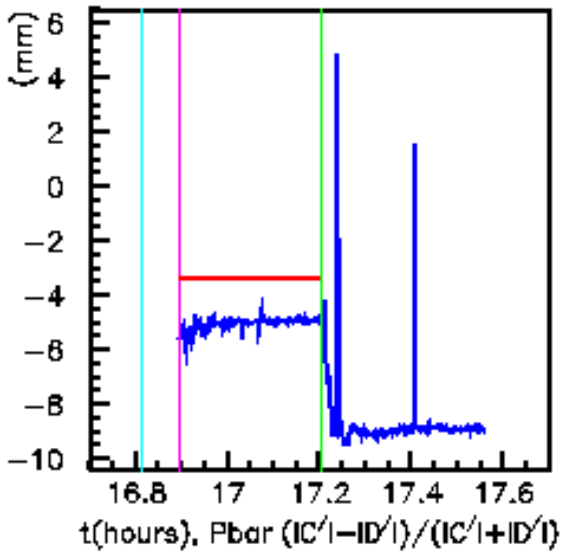
Ramp 150 to 980 GeV

Predicted Pbar position using central and proton orbits.
This prediction is valid only until ramp, when central orbit may change.

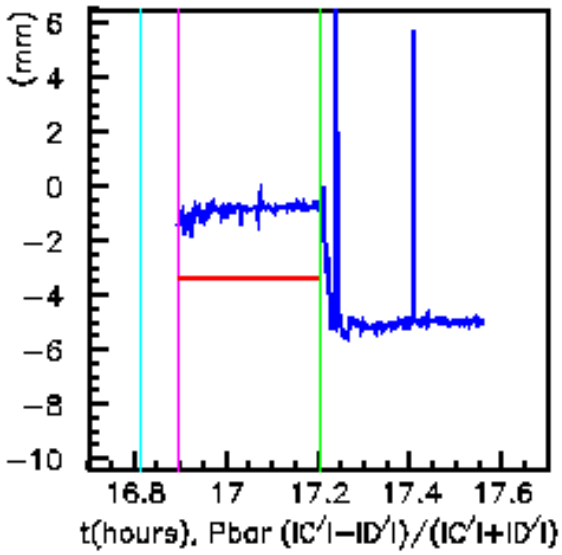
# Comments on Previous Slide

- Pbar injection comes in 9 steps with first steps bigger than last.
  - We see this.
- Obvious scale problem in position plot. We think that the directionality factors can fix this.
- Not known if big spikes are noise or due to real effects, such as cogging.
- Noise on position decreases with increasing intensity.

# Can $r_p$ and $r_{pbar}$ Fix The Scale?




$$r_p = r_{\bar{p}} = 0$$



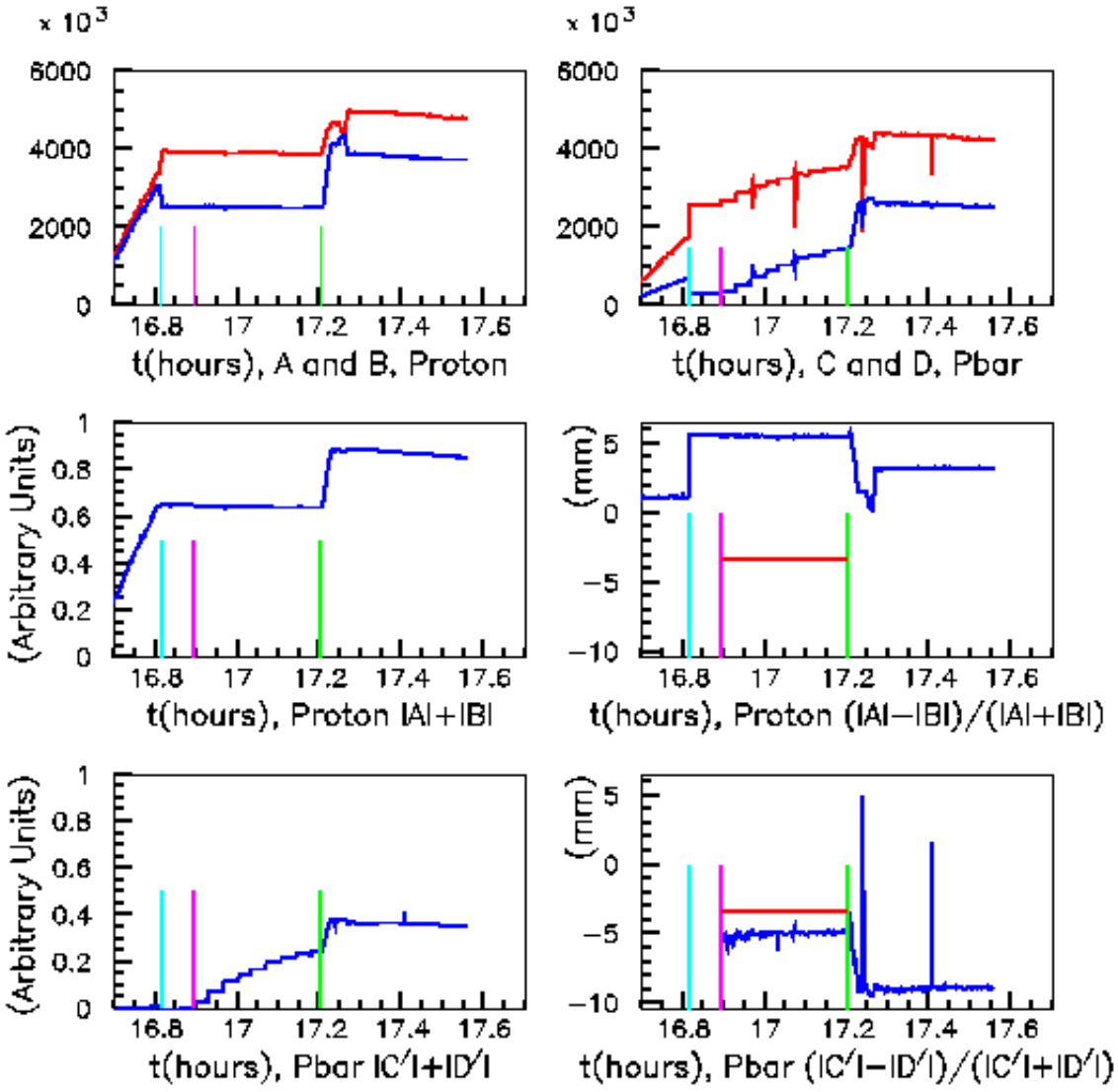

$$r_p = r_{\bar{p}} = \frac{C_0}{A_0}$$

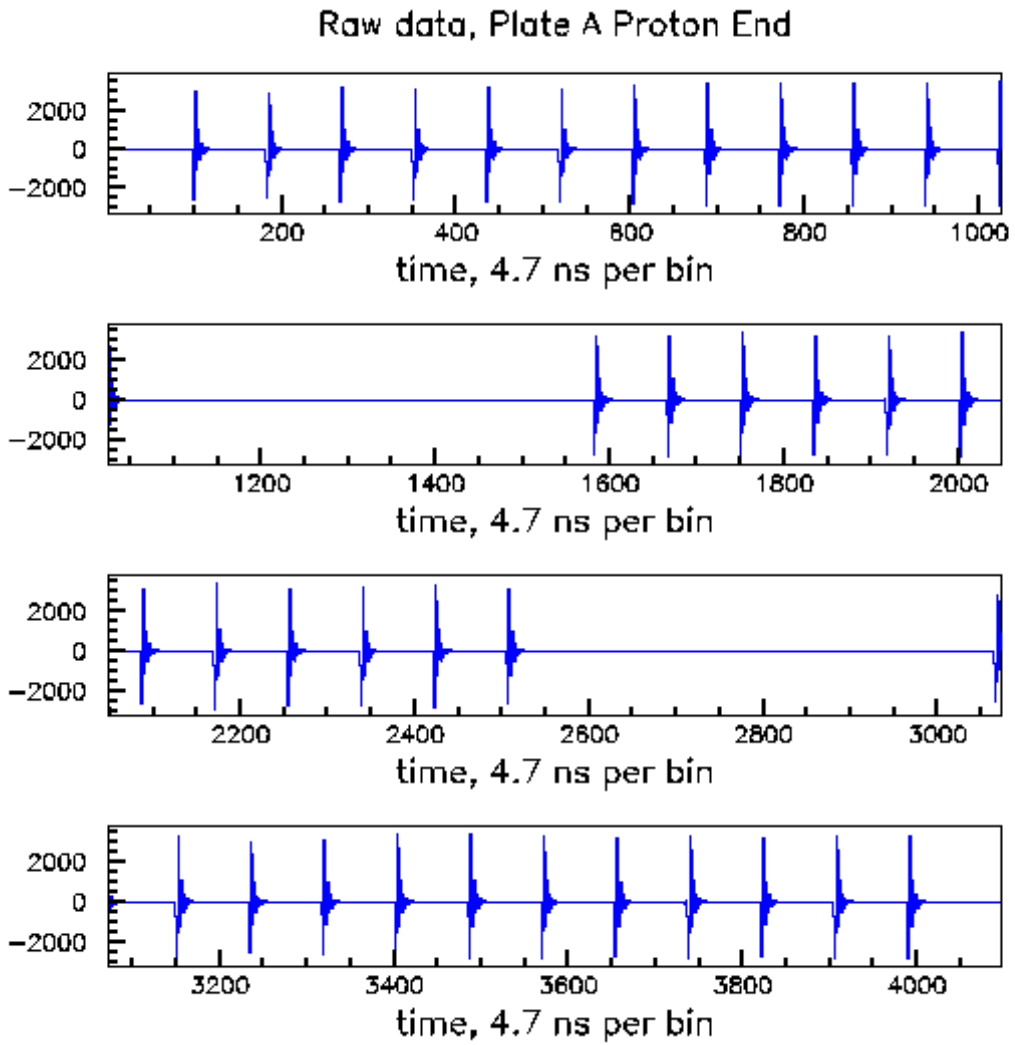
- The effect the ratios is of the right size to cover the discrepancy.
- All numbers are complex. So |1-r^2| can be > 0.

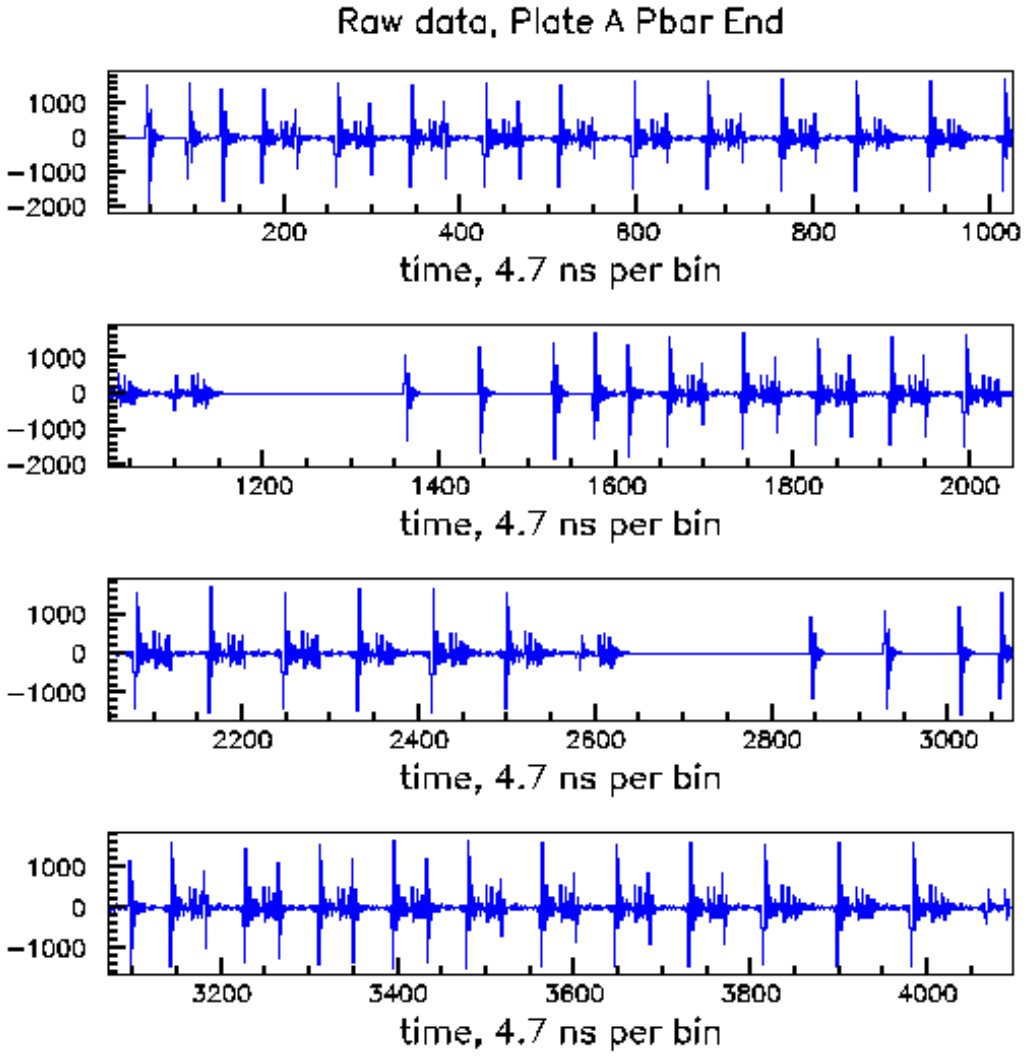
# Conclusions

- We can see clean signals for antiprotons in the presence of protons.
- We still need to measure one more calibration number before we can assess accuracy, resolution and stability.

# Backup Slides


x 10^3
6000
4000
2000
0
16.8
17
17.2
17.4
17.6
t(hours), A and B, Proton
x 10^3
6000
4000
2000
0
16.8
17
17.2
17.4
17.6
t(hours), C and D, Pbar
(Arbitrary Units)
1
0.8
0.6
0.4
0.2
0
16.8
17
17.2
17.4
17.6
t(hours), Proton |A|+|B|
(mm)
5
0
−5
−10
16.8
17
17.2
17.4
17.6
t(hours), Proton (|A|−|B|)/(|A|+|B|)
(Arbitrary Units)
1
0.8
0.6
0.4
0.2
0
16.8
17
17.2
17.4
17.6
t(hours), Pbar |C′|+|D′|
(mm)
5
0
−5
−10
16.8
17
17.2
17.4
17.6
t(hours), Pbar (|C′|−|D′|)/(|C′|+|D′|)


Raw data, Plate A Proton End
2000
0
−2000
200
400
600
800
1000
time, 4.7 ns per bin
2000
0
−2000
1200
1400
1600
1800
2000
time, 4.7 ns per bin
2000
0
−2000
2200
2400
2600
2800
3000
time, 4.7 ns per bin
2000
0
−2000
3200
3400
3600
3800
4000
time, 4.7 ns per bin


Raw data, Plate A Pbar End
1000
0
−1000
−2000
200
400
600
800
1000
time, 4.7 ns per bin
1000
0
−1000
−2000
1200
1400
1600
1800
2000
time, 4.7 ns per bin
1000
0
−1000
2200
2400
2600
2800
3000
time, 4.7 ns per bin
1000
0
−1000
3200
3400
3600
3800
4000
time, 4.7 ns per bin

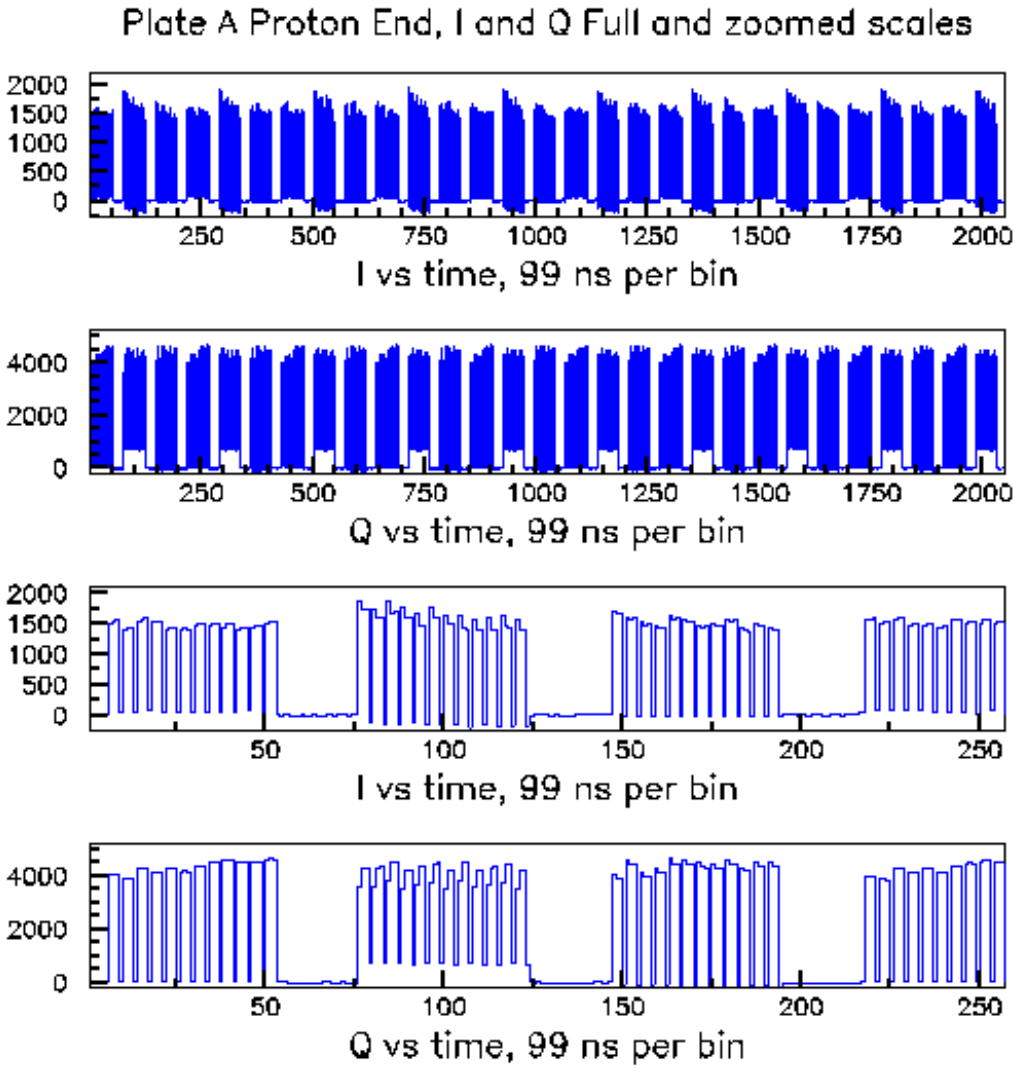


Plate A Proton End, I and Q Full and zoomed scales
2000
1500
1000
500
0
250
500
750
1000
1250
1500
1750
2000
I vs time, 99 ns per bin
4000
2000
0
250
500
750
1000
1250
1500
1750
2000
Q vs time, 99 ns per bin
2000
1500
1000
500
0
50
100
150
200
250
I vs time, 99 ns per bin
4000
2000
0
50
100
150
200
250
Q vs time, 99 ns per bin

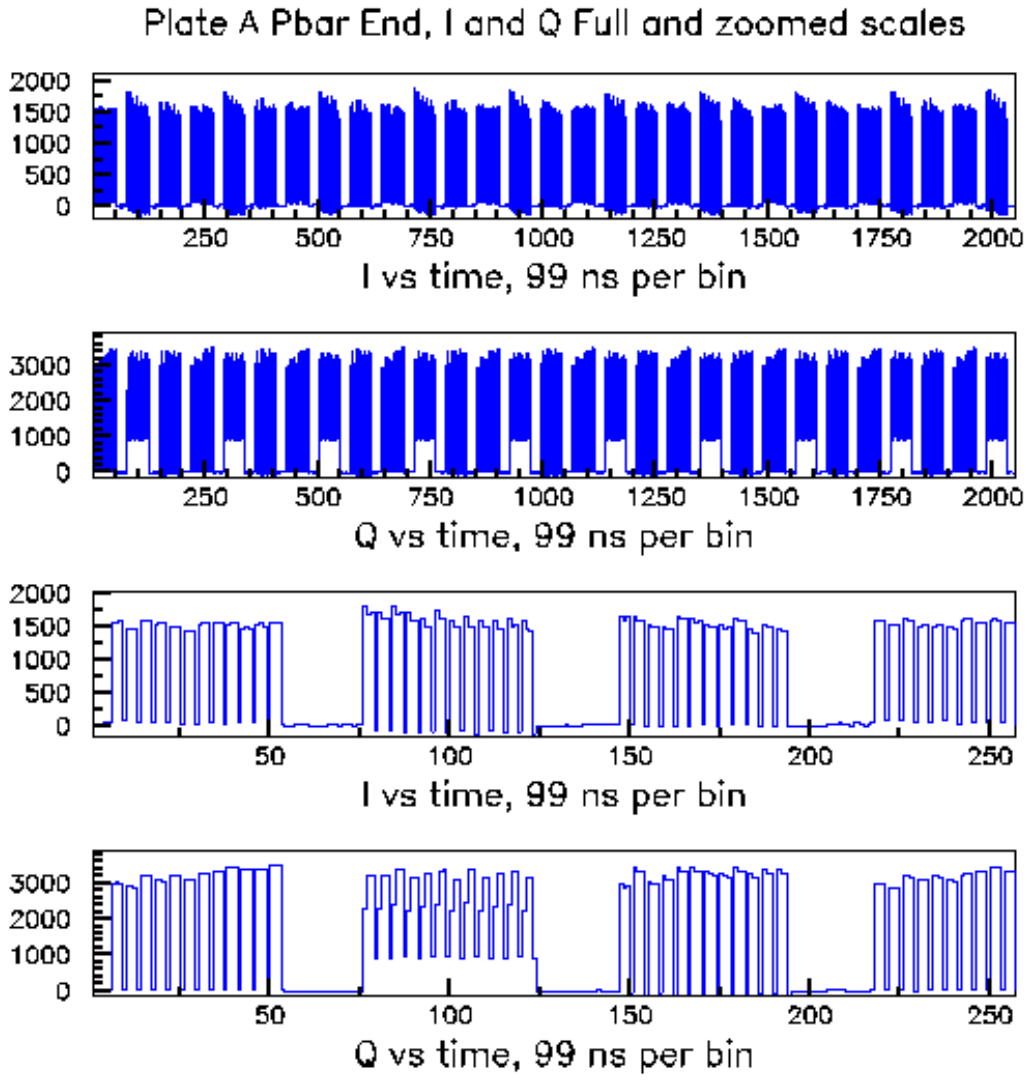


Plate A Pbar End, I and Q Full and zoomed scales
2000
1500
1000
500
0
250
500
750
1000
1250
1500
1750
2000
I vs time, 99 ns per bin
3000
2000
1000
0
250
500
750
1000
1250
1500
1750
2000
Q vs time, 99 ns per bin
2000
1500
1000
500
0
50
100
150
200
250
I vs time, 99 ns per bin
3000
2000
1000
0
50
100
150
200
250
Q vs time, 99 ns per bin